GOES-R GLM Calibration

GLM Science Meeting 2011

Bob Iacovazzi Jr.

September 20, 2011

GOES-R Calibration Definition

Calibration:

The process to determine factors for converting and correcting raw detector measurements into science data units (e.g., radiance) with the specified level of accuracy. [Calibration requirements are found in MRD Sections 3.4.2.1-7]

- *GOES-R Program Acronym and Glossary*

GOES-R Program Cal/Val Documents

Effective Date: 06-19-2009
Expiration Date: 06-19-2014
Responsible Organization: GOES-R/417

P417-R-CALVAL-0192
Version: 1.0

Geostationary Operational Environmental Satellite (GOES)

Calibration and Product Validation Strategy

June 19, 2009

Roles and Responsibilities

U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)

Effective Date: 02/14/11
Expiration Date: 02/014/16
Responsible Organization: GOES R Program/Code 417

P417-R-PLN-0101
Version 1.0

GOES-R Series Calibration/Validation Plan
Volume 1: Level 1b Data

February 2011

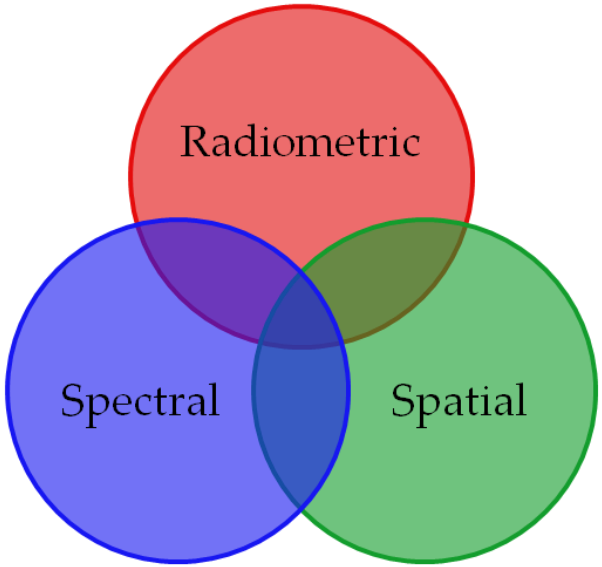
U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
NOAA Environmental Satellite, Data, and Information Service (NESDIS)
National Aeronautics and Space Administration (NASA)

Technical Details

THIS DOCUMENT IS SUBJECT TO ITAR CONTROL, AND MAY CONTAIN INFORMATION PROPRIETARY TO GOES-R VENDORS.
Check the VSDE at https://goesr2.ndc.nasa.gov to verify correct version prior to use

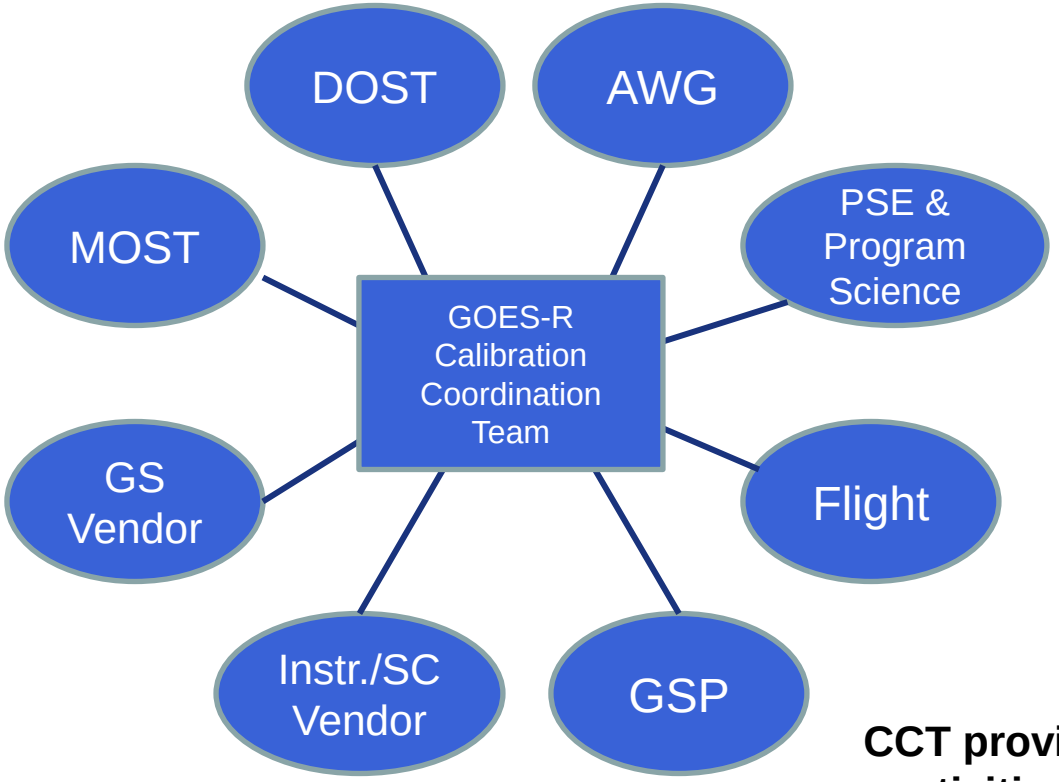
Calibration Support for GLM

- **Instrument, Spacecraft and Ground Segments Vendors**
- **GOES-R Cal/Val Working (CWG) Group Members and Partners**
  - *Flight Project*
  - *Ground Segment Project*
  - *NOAA/NESDIS/STAR*
  - *MIT Lincoln Laboratory*
  - *Field Campaign Support (NASA, NOAA, JPL, etc.)*
  - *Marshall Space Flight Center/UAH*



Calibration Coordination Team (CCT) Formed Under New PSE Leadership

Scope – ***A coordinating body to ensure efficient implementation of calibration activities throughout the GOES-R Program during all mission phases.***



GOES-R Calibration Coordination Team membership diagram

CCT members - Representatives of any group with responsibility to ensure L1b Product integrity, *e.g.,*

- PSE & Program Science
- Flight (Deputy Project Manager, Instrument Managers)
- Ground (Deputy Project Manager)
- Other CWG reps
- Vendors (Instrument, Spacecraft and Ground)
- MOST (MOM)
- DOST (DOM)
- AWG

CCT provides a forum to clarify GOES-R cal/val activities and associated member roles and responsibilities

PSE lead has the final authority on cal/val topics

Major GLM Cal-related Activities in Each Mission Phase

- **Pre-Launch**
  - Schedule determined by Flight and Vendors
    - Instrument and Test Design and Review
    - Instrument Testing and Test Verification
    - L1b Algorithm Development, Implementation and Review
- **Post-Launch Testing (PLT)**
  - Schedule determined by MOST and DOST
    - Science Test Design and Review
    - Science Tests Analysis and Verification
    - Cal Parameter Verification
    - Long-Term Monitoring Initialization
    - Performance Analysis/Anomaly Resolution
- **Mission Operational Lifetime**
  - Schedule determined by Ops
    - Long-Term Instrument and L1b Product Monitoring
    - Cal Parameter Updates
    - Anomaly Resolution

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Lockheed-Martin Pre-launch Calibration Overview

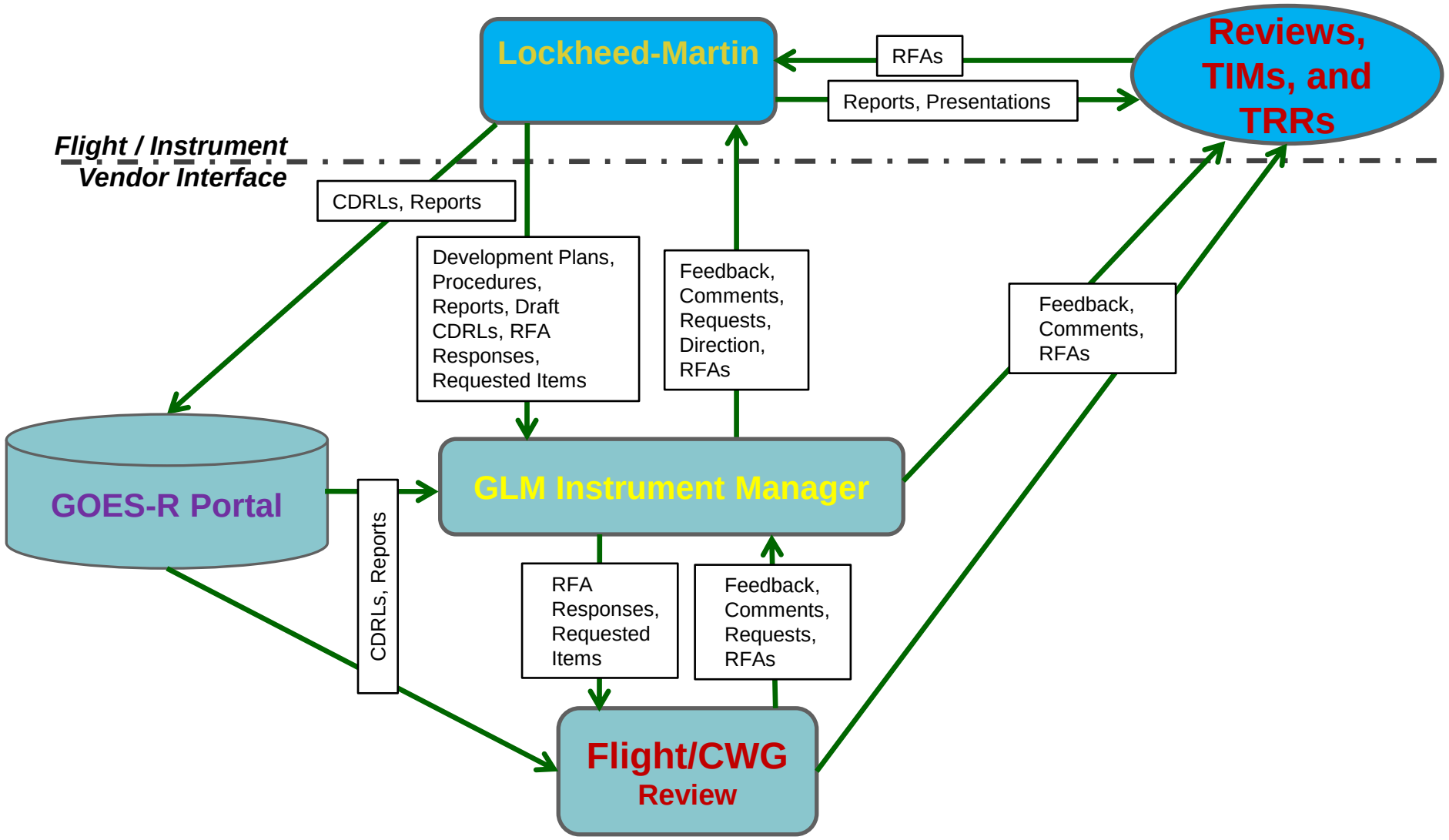
GLM is an imager and an event detector and must be radiometrically calibrated for background scenes (images) and for lightning events (optical pulses)

- Calibration activities consist of six procedures:
  - Static radiometric response (Linearity and uniformity)
  - Transient radiometric response (instrument calibration)
  - Performance test (detection efficiency, false event rate, etc.)
  - Field of view
  - Spectral response
  - Spacecraft motion and jitter simulation

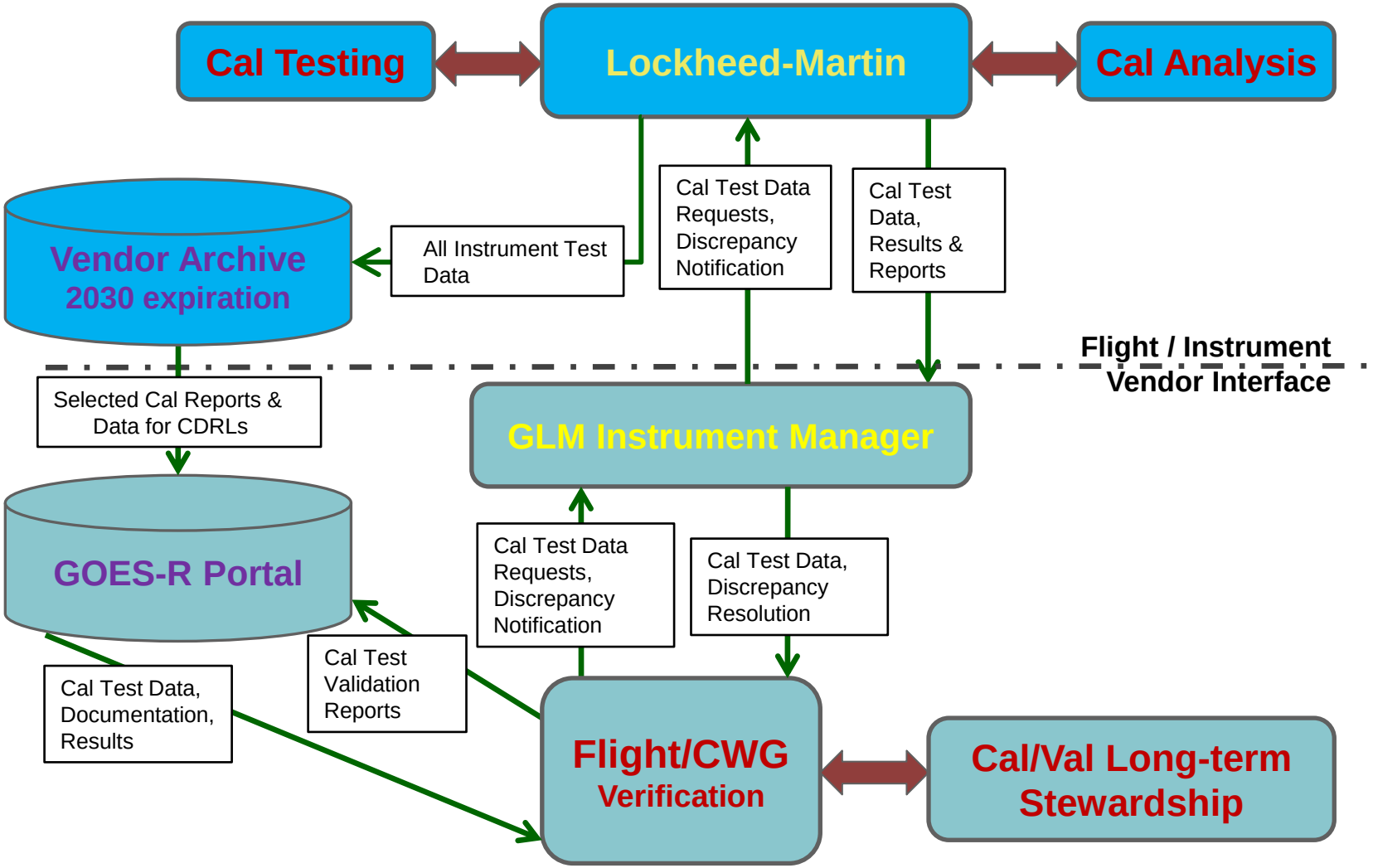
Lockheed-Martin Pre-launch Calibration Overview

- Calibration is performed in a class 10K clean room at LMATC
- Principal equipment includes
  - Large integrating sphere (*NIST Certified*)
  - Integrating sphere with co-aligned optical pulse emitter
  - Two precision rotary stages
  - Collimator
  - Tunable laser
  - GLM GSD including a dedicated lightning calibration computer system

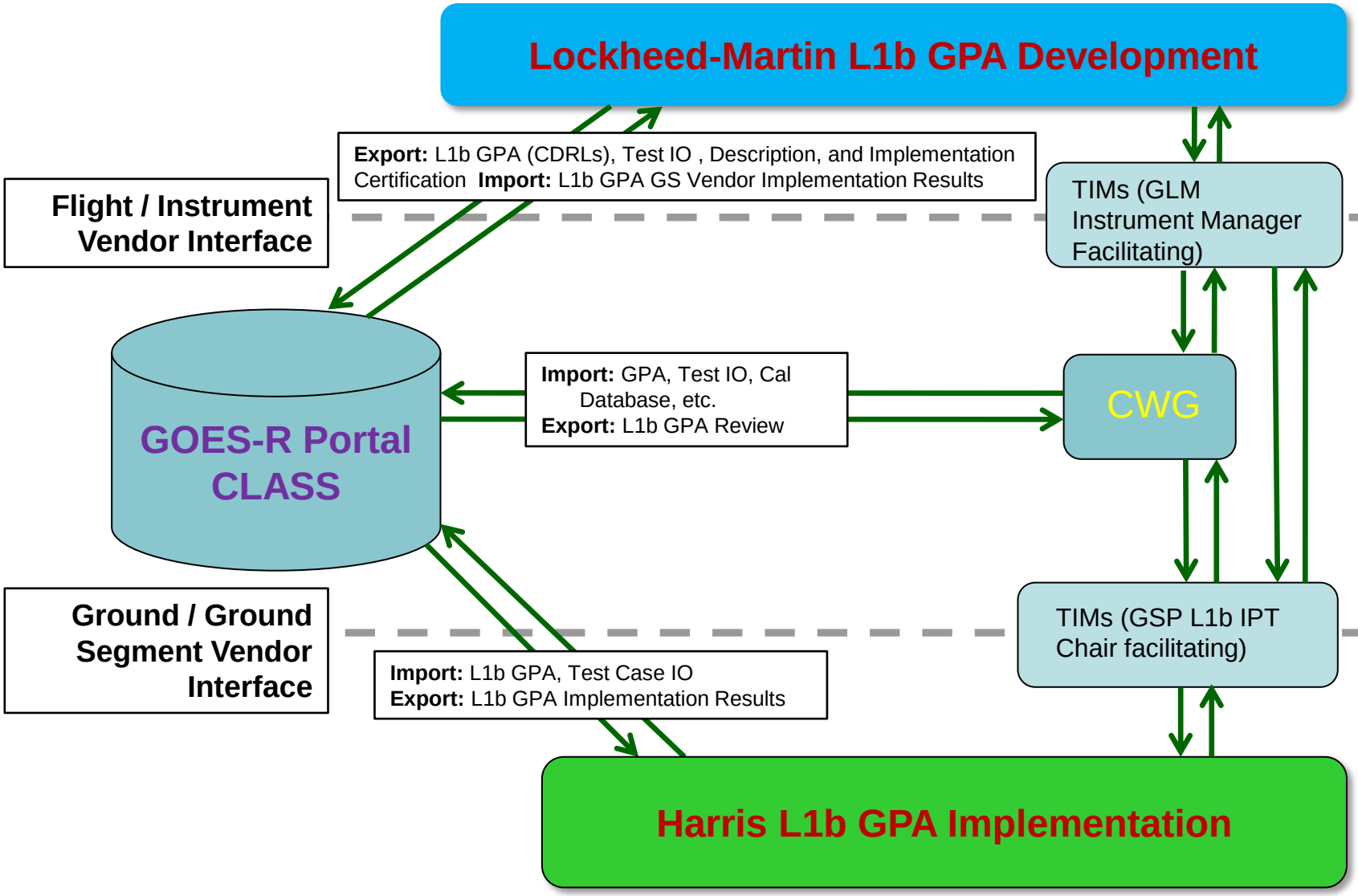
Pre-Launch Design & Development Review



Pre-Launch Calibration Data Management



L1b Ground Processing Algorithm (GPA) Development and Implementation



Major GLM Cal-related Activities in Each Mission Phase

- Pre-Launch
  - ➢ Schedule determined by Flight and Vendors
    - ❖ Instrument and Test Design and Review
    - ❖ Instrument Testing and Test Verification
    - ❖ L1b Algorithm Development, Implementation and Review

- **Post-Launch Testing (PLT)**
  - **➢ Schedule determined by MOST and DOST**
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- **Mission Operational Lifetime**
  - **➢ Schedule determined by Ops**
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    - **❖ Cal Parameter Updates**
    - **❖ Anomaly Resolution**

Postlaunch Instrument Calibration Data Flow

NOAA Satellite Operations Facility (NSOF)

L1b Data, GLM L2+ GRB

MM, PG, PD and DE

MLS

2-Day Store

L1b, L2+ Products, Instr. Cal Data

Instrument Calibration Data Via Terrestrial Data Link

GAS

CWG

CLASS

Updated Calibration Parameter Tables

Instrument Radiometric, Spectral. Spatial Calibration Data Quality Assurance for GOES Series-R

- Post Launch Verification
- Long-term Instr. Monitoring
- Deep-Dive Calibration Analysis and L1b Product Anomaly Resolution
- Calibration Parameter Updates

Wallops Command and Data Acquisition System (WCDAS)

Fairmount, WV (RBU)

L1Data, GLM L2+ GRB

L0 Data

Instrument Calibration Data

- GLM Background Images
- Calibration-relevant instrument housekeeping & engineering data

Cal L0 and Processing Data

Product Generation Operational Environment

L1b Calibrated Data

Ground Processing Algorithm

L0 & Input Data

Cal Parameter Tables and Algorithms (Wallops only)

Product Generation Development Environment

Experimental L1b Calibrated Data

Experimental Ground Processing Algorithm

L0 & Input Data

L0 Data

CLASS

L1b Product Performance Monitoring and Anomaly Resolution

WCDAS/RBU-SOZ

Instr. Telemetry

Mission Mgmt: Instr. Temps, etc. H & S Monitor

L1b (GRB)

Mission Mgmt: GRB Uplink

Product Generation/ Distribution: Create L0, L0 to L1b processing and GRB generation.

CAL (RDL)

L0

L0

5-Day RDR

DE in WCDAS SOZ

Anomaly Resolution

CALVAL Workstation Gov't Tools

SOZ-wide Access to Cal Terminals

CLASS

L1b (GRB)

NSOF-SOZ

Mission Mgmt: GRB Downlink & Monitor

2-day

MLS

2-day

Product Generation: Product Performance Monitor

MLS

Anomaly Resolution

SOZ-wide Access to Cal Terminals

CALVAL Workstation Gov't Tools

L1b, CAL

GAS

External Org

Anomaly Resolution

Org GOES-R Terminals

External Org Workstations
Automated Cal Data Acquisition
GOES-R Integrated Cal/Val
Instrument Performance Web Displays

Org LS

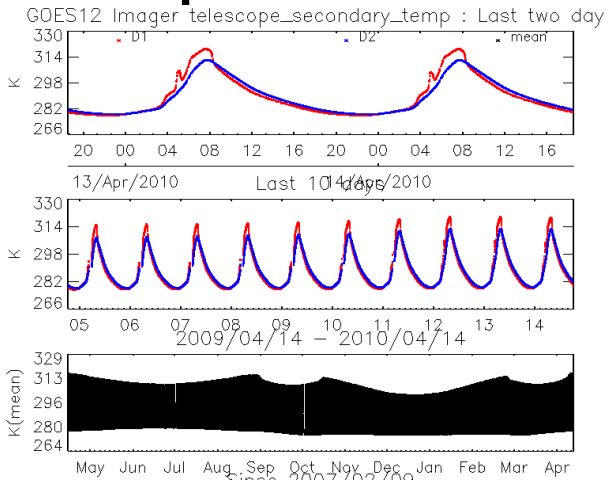
Org Firewall

CLASS

Post-Launch Calibration Evaluation

Instrument Performance Monitoring

- **Tracking of thermal stability of GLM components**

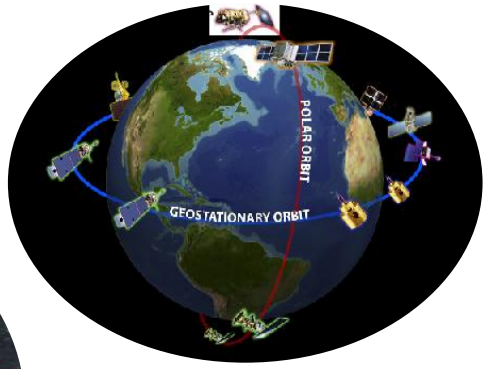


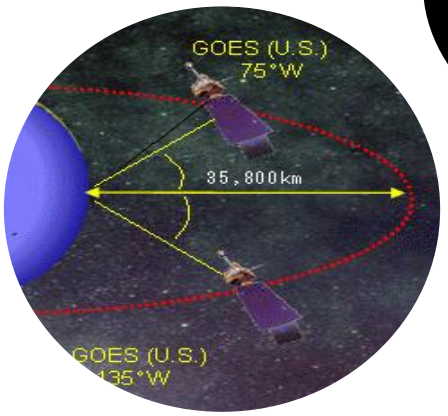
- **Quick views of GLM background images, output every 2.5 minutes**

Long-term Radiometric Trending

- Comparison of GOES-E/W GLM background images
- Ratio of GLM background image radiances with ABI and other instruments

GEO-LEO



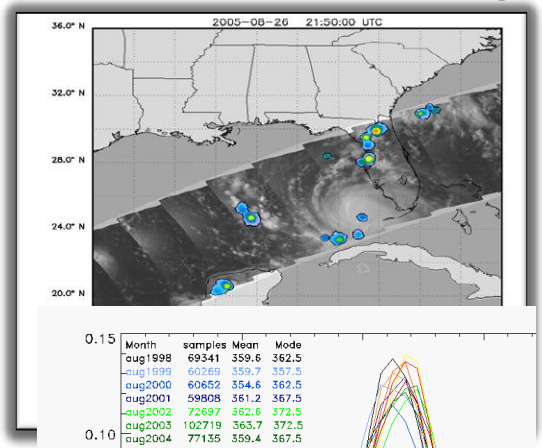


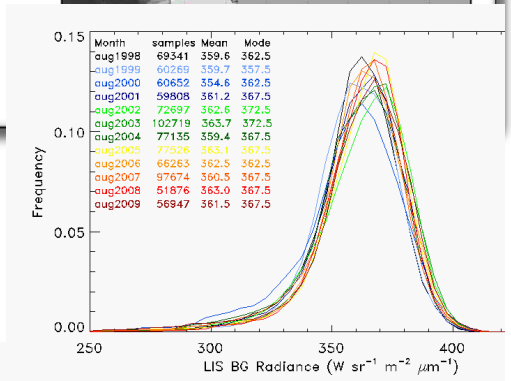
GEO-GEO

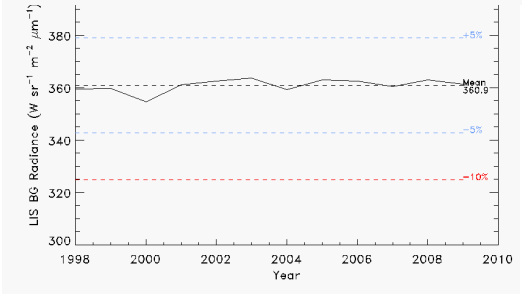
Post-Launch Calibration Evaluation

Long-term Radiometric Trending

- Several methods have applicability to determining lifetime GLM radiometric calibration drift:
  - Vicarious calibration using deep convective clouds (DCC), sun glint, and deserts
  - Radiance bias estimate using NWP and radiative transfer models







Sonoran Desert and White Sands Site Characterization

- Sonoran Desert has been used for GOES Imager long-term radiometric trending
- White Sands is a possible new site for GOES-R
- Characterization of BRDF to remove seasonal signal variation for vicarious calibration.

Summary

- GLM calibration leveraging diverse complementary technical capabilities
- Comprehensive GOES-R GLM Cal/Val Strategy and Plan developed to ensure product quality
  - Pre-launch Vendor implementation and Government review processes for GLM calibration testing and data, and ground processing algorithm
  - Post-launch
    - GLM calibration-relevant data capture and monitoring to support anomaly resolution
    - Long-term calibration trending